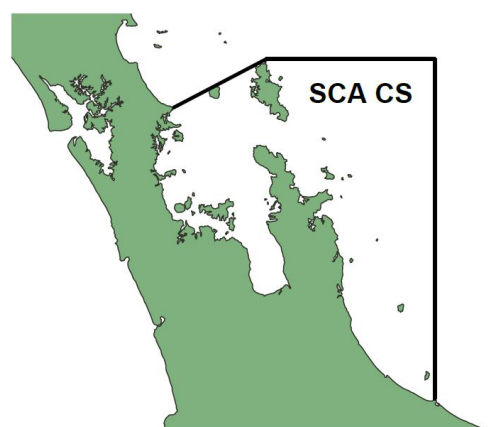


SCALLOPS Coromandel (SCA CS)

(*Pecten novaezelandiae*)
Kuakua, Tipa



1. FISHERY SUMMARY

Coromandel scallops (SCA CS) were introduced into the Quota Management System (QMS) on 1 April 2002 with a Total Allowable Catch (TAC) of 48 t, comprising a Total Allowable Commercial Catch (TACC) of 22 t, allowances of 7.5 t for recreational and customary fisheries, and an allowance of 11 t for other sources of mortality. In-season increases in TAC were made each year until 1 April 2013 when the TAC was increased to 131 t, comprising a TACC of 100 t, allowances of 10 t for recreational and customary fisheries, and 11 t for other sources of mortality (Ministry for Primary Industries 2013). Following a review (Ministry for Primary Industries 2016), on 1 April 2016 the TAC was reduced to 81 t, and the TACC was reduced to 50 t (allowances for recreational, customary, and other mortality were not changed). Following a further review (Fisheries New Zealand 2022a), on 1 April 2022 the SCA CS QMA was closed to the harvest of scallops, except for within two defined areas (one around Te Hauturu-o-Toi/Little Barrier Island and one in Colville Channel); the TAC was reduced to 19 t, comprising a reduced TACC of 5 t, a reduced recreational allowance of 3 t, a reduced allowance of 1 t for other sources of mortality, and an unchanged allowance of 10 t for customary fisheries (Table 1; values all in meatweight: adductor muscle plus attached roe) (Minister for Oceans and Fisheries 2022). Camera-based surveys carried out in 2022 in these two areas showed serious declines in scallop abundance for both sites since the last surveys in 2021. Because of these declines, the Minister for Oceans and Fisheries decided in December 2022 to implement an emergency measure under section 16 of the Fisheries Act 1996 to immediately close these areas to fishing (Fisheries New Zealand 2022b). Following public consultation, the fishery closure continued from 1 April 2023 under a section 11 sustainability measure (Fisheries New Zealand 2023). The closure does not apply to scallops taken under customary fishing authorisations, which continue to be managed by tangata kaitiaki.

Table 1: Total Allowable Catch (TAC, t), customary, recreational, and other sources of mortality allowances (t), and TACC (t) set on 1st October each year for SCA CS since introduction into the QMS.

Year	TAC	Customary	Recreational	Other mortality	TACC
2002–12	48	7.5	7.5	11	22
2013–15	131	10	10	11	100
2016–21	81	10	10	11	50
2022	19	10	3	1	5
2023–24	11	10	–	1	–

1.1 Commercial fisheries

Until it closed on 1 April 2022, SCA CS supported a regionally important commercial fishery situated between Cape Rodney at Leigh in the north and Town Point near Tauranga in the south. Fishing has been conducted within discrete beds around Little Barrier Island, east of Waiheke Island, at Colville, north of Whitianga (to the west and south of the Mercury Islands), and in the Bay of Plenty (principally off Waihi, and around Motiti Island and Slipper Island). CELR data suggest Waiheke (Scallop Statistical Area 2X) has not supported significant fishing since 1991–92 (when about 56 t meat was landed) and was last fished in 2014 (under 3 t landed). In 2011, fishers discovered that a large area in the Hauraki Gulf contained good densities of large scallops, which supported a large proportion of the commercial fishery from 2011 to 2013. This new, deeper (45–50 m water depth) bed was found mainly within Statistical Area 2W and a smaller portion in 2S. This bed was surveyed for the first time in 2012 confirming a high biomass consisting of predominantly large scallops. Results of an industry-based survey suggested that biomass in the surveyed part of that area was very low in 2015.

All commercial fishing was by dredge, with fishers preferring self-tipping ‘box’ dredges (1.5–2.4 m wide, fitted with a rigid tooth bar on the leading bottom edge) to the ‘ring-bag’ designs used in the Challenger (Nelson/Marlborough) and Chatham Island fisheries. The fishing year applicable to this fishery is from 1 April to 31 March. The Coromandel commercial scallop fishing season ran from 15 July to 21 December each year. Until the 1994 season, the minimum legal size was 100 mm shell length. (All references to ‘shell length’ in this chapter refer to the maximum linear dimension of the shell, in an anterior-posterior axis.) From 1995 onwards, a new minimum legal size of 90 mm shell length was applied in the commercial fishery (but not in the recreational or customary fisheries) as part of a management plan comprising several new measures. The new commercial size limit was developed between Coromandel Scallop Fishermen’s Association (CSFA, which represents the SCA CS commercial fishing industry) and non-commercial fishers (Ministry of Fisheries 2007).

A wide variety of effort controls (e.g., dredge size, fishing hours, or non-fishing days) and daily/explicit seasonal catch limits specified in meatweight (adductor muscle with roe attached) have been imposed, many of which remained in place after the stock was introduced into the QMS.

Catch and catch rates from the Coromandel fishery were variable both within and among years, a characteristic typical of most scallop fisheries worldwide which are highly variable even in the absence of fishing (Smith et al. 2016). Catch rates typically declined as each season progressed, but such declines were highly variable and depletion analysis was not successful in assessing start-of-season biomass (Cryer 2001). Landings and catch limits from the Coromandel fishery are shown in Figure 1 and Table 2. Since 1980, when the fishery was considered to be fully developed, landings have varied more than 30-fold from less than 6 t to over 188 t (meatweight). The lowest recorded landings total was in 1999. In 2021, four vessels operated in the commercial fishery.

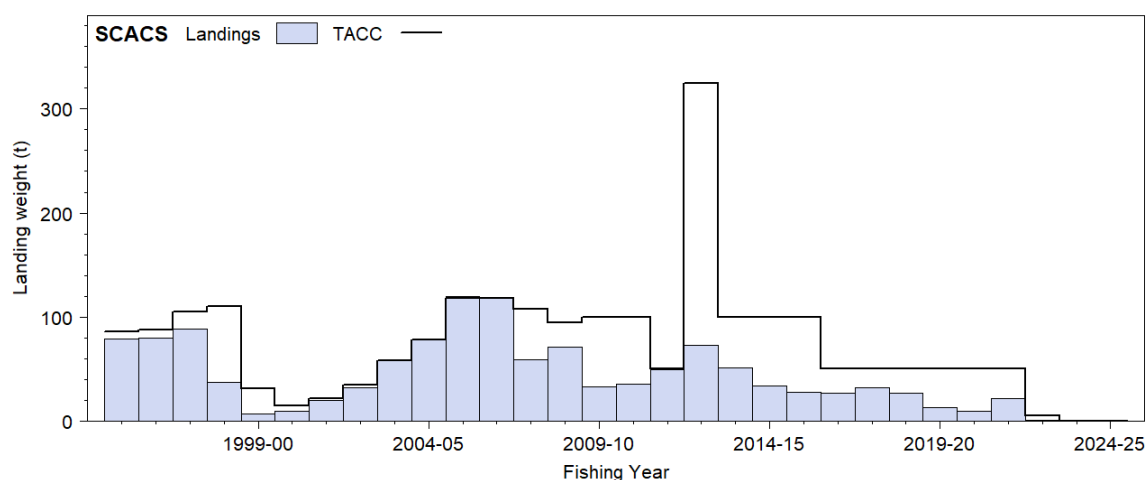


Figure 1: Commercial landings and catch limits for SCA CS (Coromandel) since 1995–96. TACC refers to the catch limit (including any in-season increase), and weight refers to meatweight.

Table 2: Commercial catch limits and landings (t meatweight or greenweight) from the Coromandel fishery since 1974. Data before 1986 are from Fisheries Statistics Unit (FSU) forms. Landed catch figures come from Monthly Harvest Return (MHR) forms, Licensed Fish Receiver Return (LFRR) forms, and from the ‘Landed’ section of Catch Effort and Landing Return (CELR) forms, whereas estimated catch figures come from the effort section of CELRs and are prorated to sum to the total CELR greenweight. ‘Hauraki’ = Statistical Areas 2X and 2W, ‘Mercury’ = 2L and 2K, ‘Barrier’ = 2R, 2S, and 2Q, ‘Plenty’ = 2A–2I. Seasonal catch limits (since 1992) have been specified as Annual Catch Entitlement or on permits in meatweight (Green* assumes the gazetted meatweight recovery conversion factor of 12.5% and probably overestimates the actual greenweight taken in most years). † 1991 landings include about 400 t from Colville; ‡ a large proportion of the 2011, 2012, and 2013 landings were from a relatively deep (45–50 m) area of Statistical Area 2W fished for the first time in 2011; § 2021 landings from Barrier comprised 40 t from Te Hauturu-o-Toi/Little Barrier Island and 89 t from Colville Channel, the latter fished for the first time in 2021; – indicates no catch limits set, no reported catch, or data not available for this update.

Season	Catch limits (t)		Landings (t)			Scaled estimated catch (t green)			
			MHR	CELR		Hauraki	Mercury	Barrier	Plenty
	Meat	Green*	Meat	Meat	Green				
1974	–	–	–	–	26	0	26	0	0
1975	–	–	–	–	76	0	76	0	0
1976	–	–	–	–	112	0	98	0	14
1977	–	–	–	–	710	0	574	0	136
1978	–	–	–	–	961	164	729	3	65
1979	–	–	–	–	790	282	362	51	91
1980	–	–	–	–	1 005	249	690	23	77
1981	–	–	–	–	1 170	332	743	41	72
1982	–	–	–	–	1 050	687	385	49	80
1983	–	–	–	–	1 553	687	715	120	31
1984	–	–	–	–	1 123	524	525	62	12
1985	–	–	–	–	877	518	277	82	0
1986	–	–	–	–	1 035	135	576	305	19
1987	–	–	–	–	1 431	676	556	136	62
1988	–	–	–	–	1 167	19	911	234	3
1989	–	–	–	–	360	24	253	95	1
1990	–	–	–	–	903	98	691	114	0
1991	–	–	–	–	1 392	472†	822	98	0
1992–93	154	1 232	–	–	901	67	686	68	76
1993–94	132	1 056	–	–	455	11	229	60	149
1994–95	66	528	–	–	323	17	139	48	119
1995–96	86	686	–	79	574	25	323	176	50
1996–97	88	704	–	80	594	25	359	193	18
1997–98	105	840	–	89	679	26	473	165	15
1998–99	110	880	–	37	204	1	199	2	1
1999–00	31	248	–	7	47	0	12	17	18
2000–01	15	123	–	10	70	0	24	2	44
2001–02	22	176	–	20	161	1	63	85	12
2002–03	35	280	32	31	204	0	79	12	112
2003–04	58	464	58	56	451	63	153	13	223
2004–05	78	624	78	78	624	27	333	27	237
2005–06	118	944	119	121	968	21	872	75	0
2006–07	118	944	118	117	934	28	846	60	0
2007–08	108	864	59	59	471	51	373	45	2
2008–09	95	760	71	72	541	12	509	15	5
2009–10	100	800	33	33	267	12	184	71	0
2010–11	100	800	35	35	281	11	110	160	1
2011–12	50	400	50	50	402	220‡	160	20	0
2012–13	325	2600	73	73	584	572‡	1	11	0
2013–14	100	800	51	68	545	344‡	133	68	0
2014–15	100	800	34	35	280	27	186	64	4
2015–16	100	800	27	33	264	11	153	32	0
2016–17	50	400	27	27	216	0	94	152	0
2017–18	50	400	32	32	307	22	204	81	0
2018–19	50	400	27	27	220	9	106	105	0
2019–20	50	400	13	13	113	0	73	40	0
2020–21	50	400	10	10	80	0	21	60	0
2021–22	50	400	22	21	167	7	31	129§	1
2022–23	5	40	1	1	8	0	0	8	0
2023–24	0	0	0	0	0	0	0	0	0
2024–25	0	0	0	0	0	0	0	0	0

From 1992 up to and including the 2012 fishing year, the base TACC for SCA CS was 22 t; in-season increases in TAC were considered if requested by stakeholders. All such requests were made by the CSFA. Decisions to increase the TAC in-season were usually supported by estimates of biomass derived

from (mostly) annual surveys and required a consultation process with all relevant stakeholders, prior to being implemented. In 2013, the base TACC was raised from 22 t to 100 t. A key purpose of the Minister's decision to increase the TAC was to reduce management and research costs by reducing the need for the annual survey and consultation processes that were required to support requests for increases in the TAC. It was recognised: that the original TAC was set when the fishery was at a low point, due to 'black gill' disease and a prolific outbreak of a parchment tube worm; that subsequent performance of the fishery had improved; the significant bed in the Hauraki Gulf had been discovered; and a 'CPUE limit rule' was in place to mitigate risks around rapid declines (Ministry for Primary Industries 2013). The 2016 decrease in the TAC recognised that the large commercial scallop bed in the gulf had died off and was no longer fished (Ministry for Primary Industries 2016).

Between 2010 and when the fishery closed on 1 April 2022, a non-statutory 'CPUE limit rule' was implemented as an additional management strategy by CSFA. The approach aimed to ensure that scallop beds were not fished below a specified level of CPUE (Haist & Middleton 2014). Once a specified lower CPUE limit had been reached in an area of the fishery, fishing within that area ceased for the remainder of the season. A formal Management Strategy Evaluation (Haist & Middleton 2014) indicated that similar mean catches could be attained at similar risk levels from the CPUE limit approach as were attained under the survey-based approach. Smith et al. (2016) raised some concerns about the CPUE limit approach. The CPUE rule does not translate into a fixed fishing mortality. In productive areas, where CPUE can exceed 200 kg/hr, a reduction to a limit of 75 kg/hr translates into an instantaneous fishing mortality rate of almost 1 (about 63% per annum), so that growth overfishing can occur in these areas. Additionally, these higher density areas may contribute most of the fertilised larvae because scallops likely need to be in close proximity for eggs to be successfully fertilised. Thus, removing a high proportion of scallops in these areas may remove important spawning aggregations and reduce fertilised egg production, which may have negative implications for sustainability.

To implement this approach, CSFA have carried out a logbook programme that involved recording fishery data (catch and effort) at a fine spatial scale within the broader CELR statistical reporting areas. A 'hard limit' of 50 kg/hour (greenweight) was adopted as the absolute lower limit for the fishery in an area, because the simulations by Haist & Middleton (2014) indicated that this would meet the Harvest Strategy Standard's performance requirements. However, an additional 'soft limit' of 75 kg/hr was adopted, with only exploratory fishing permitted when catch rates were below this level (and above the hard limit). Meatweight recovery, and the proportion of legal-sized scallops in the catch, were also monitored and used to determine fishing patterns. In addition, the fishery was open for five days per week and daily catch limits were applied, by agreement of the quota holders. This CPUE limit rule' approach was reviewed by Williams et al. (in review), see Section 5.1.

1.2 Recreational fisheries

The recreational and commercial fisheries were, largely, spatially separate in SCA CS with much of the near shore area closed to commercial scallop fishing (Ministry for Primary Industries 2013). Until 2006, the recreational scallop season ran from 15 July to 14 February, but in 2007 the season was changed to run from 1 September to 31 March. Until the fishery fully closed in December 2022, fishers could take up to 20 scallops per day with a minimum legal size of 100 mm shell length. Estimates of the recreational scallop harvest from SCA CS are shown in Table 3. The harvest estimates provided by telephone-diary surveys between 1993 and 2001 are no longer considered reliable. A Recreational Technical Working Group concluded that these harvest estimates should be used only with the following qualifications: a) they may be very inaccurate; b) the 1996 and earlier surveys contain a methodological error; and c) the 2000 and 2001 estimates are implausibly high for many important fisheries.

In response to these problems and the cost and scale challenges associated with onsite methods, a National Panel Survey was conducted for the first time throughout the 2011–12 fishing year (Wynne-Jones et al. 2014). The panel survey used face-to-face interviews of a random sample of 30 390 New Zealand households to recruit a panel of fishers and non-fishers for a full year. The panel members were

contacted regularly about their fishing activities and harvest information was collected in standardised phone interviews.

Table 3: Estimates of the recreational harvest of scallops from SCA CS. Number, number of scallops; green, greenweight; meat, meatweight (assuming 12.5% recovery of meatweight from greenweight). The 2007–08 estimates are for a 90-day period of the summer in a defined area (Coromandel Peninsula) within SCA CS only.

Year	Area	Survey method	Number	CV	Green (t)	Meat (t)	Reference
1991–93	SCA CS	Phone-diary	654 000	0.14	60–70	8–9	Teirney et al. (1997)
1996	SCA CS	Phone-diary	614 000	0.12	62	8	Bradford (1998)
1999–2000	SCA CS	Phone-diary	257 000	1.01	30	4	Boyd & Reilly (2004)
2000–01	SCA CS	Phone-diary	472 000	0.47	55	7	Boyd et al. (2004)
2007–08	Coro. peninsula	Creel survey	205 400	0.09	24	3	Holdsworth & Walshe (2014)
2011–12	SCA CS	Panel survey	605 466	0.27	67	8	Wynne-Jones et al. (2014)
2017–18	SCA CS	Panel survey	335 864	0.18	37	5	Wynne-Jones et al. (2019)
2022–23	SCA CS	Panel survey	–	–	–	–	Heinemann & Gray (2024)

A creel survey was conducted in 2007–08 to assess the feasibility of estimating the recreational catch in that part of the Coromandel scallop fishery from Cape Colville to Hot Water Beach (Holdsworth & Walshe 2014). The study was based on an access point (boat ramp) survey using interviewers to collect catch and effort information from returning fishers and was conducted from 1 December 2007 to 28 February 2008 (90 days) during the peak of the scallop season.

The national panel survey was repeated during the 2017–18 and 2022–23 fishing years using very similar methods to produce directly comparable results (Wynne-Jones et al. 2019, Heinemann & Gray 2024). The annual recreational harvest level is likely to vary substantially through time. Most scallop beds accessible to recreational fishers were closed from April 2022, with the whole of SCA CS closed from December 2022.

There is no fine scale reporting of the location of the recreational harvest within the SCA CS QMA. No information is collected or reported on the scallop beds where fishing has occurred or on any harvest outside the recognised beds.

For further information on recreational fisheries refer to section 1.2 of the Introduction – Scallops chapter.

1.3 Customary fisheries

The information on Māori customary harvest under the provisions made for customary fishing can be limited (Table 4). These numbers are likely to be an underestimate of customary harvest as only the catch approved and harvested in kilograms and numbers are reported in the table.

Table 4: Fisheries New Zealand records of customary harvest of scallops (reported as greenweight and numbers) taken from the Coromandel scallop fishery, 2005–06 to present. –no data.

Fishing year	Weight (kg)		Numbers	
	Approved	Harvested	Approved	Harvested
2005–06	–	–	500	500
2006–07	–	–	240	180
2007–08	355	310	2 390	1 340
2008–09	–	–	2 390	2 090
2009–10	100	40	1 260	1 000
2010–11	325	150	1 450	1 400
2011–12	125	125	140	0
2012–13	75	75	80	80
2013–14	–	–	–	–
2014–15	–	–	120	120
2015–16	–	–	500	300
2016–17	–	–	400	320
2017–18	–	–	300	300
2018–19	–	–	600	493
2019–20	–	–	–	–
2020–21	–	–	100	22
2021–22	–	–	–	–

No customary harvest reports since 2020–21.

For further information on customary fisheries refer to section 1.3 of the Introduction – Scallops chapter.

1.4 Unreported catch

For information on unreported catch refer to section 1.4 of the Introduction – Scallops chapter.

1.5 Other sources of mortality

Research on the incidental effects of commercial scallop dredges in the Coromandel scallop fishery showed that scallops encountered by box dredges compared with scallops collected by divers had quite high mortality (about 20–30% mortality but potentially as high as 50% for scallops that are returned to the water; i.e., those just under the minimum legal size) (Cryer & Morrison 1997). The incidental mortality caused by dredging substantially changed the shape of yield-per-recruit curves for Coromandel scallops, causing generally asymptotic curves to become domed and decreasing estimates of F_{max} and $F_{0.1}$. Field experiments (Talman et al. 2004) and modelling (Cryer et al. 2004) suggest that dredging reduces habitat heterogeneity, increases juvenile mortality, makes yield-per-recruit curves even more domed, and decreases estimates of F_{max} and $F_{0.1}$ even further (Cryer & Parkinson 2006).

For further information on other sources of mortality refer to section 1.5 of the Introduction – Scallops chapter.

2. BIOLOGY

The growth of scallops within the Coromandel fishery is variable among areas, years, seasons, depths, and probably among substrates. In the Hauraki Gulf, scallops have been estimated to grow to 100 mm shell length in 18 months or less, whereas this can take three or more years elsewhere (Table 5). There is a steep relationship with depth and scallops in shallow water grow much faster than those in deeper water. This is not a simple relationship, however, because scallops in some very deep beds (e.g., Rangaunu Bay and Spirits Bay in the Far North, both deeper than 40 m) appear to grow at least as fast as those in favourable parts of the Coromandel fishery. Food supply undoubtedly plays a role (Macdonald et al. 2016).

A variety of studies (Dredge et al. 2016, Macdonald et al. 2016) suggest that average natural mortality in the Coromandel fishery is quite high at $M = 0.50 \text{ y}^{-1}$ (instantaneous rate), and maximum age in unexploited populations is thought to be about 6 or 7 years.

Table 5: Estimates of biological parameters.

Stock	Estimates		Source
1. Natural mortality, M			
Motiti Island	0.4–0.5		Walshe 1984
2. Weight = $a(\text{length})^b$	a	b	
Coromandel fishery	0.00042	2.662	Cryer & Parkinson 1999
3. von Bertalanffy parameters	L_∞	K	
Motiti Island (1981–82)	140.6	0.378	Walshe 1984
Hauraki Gulf (1982–83)	115.9	1.200	Walshe 1984
Whitianga (1982)	114.7	1.210	Data of L.G. Allen, analysed by Cryer & Parkinson 1999
Whitianga (1983)	108.1	1.197	Data of L.G. Allen, analysed by Cryer & Parkinson 1999
Whitianga (1984)	108.4	0.586	Data of L.G. Allen, analysed by Cryer & Parkinson 1999
Coromandel fishery (1992–97)	108.8	1.366	Cryer & Parkinson 1999
Whitianga mean depth 10.6 m	113.5	1.700	Cryer & Parkinson 1999
Whitianga mean depth 21.1 m	109.0	0.669	Cryer & Parkinson 1999
Whitianga mean depth 29.7 m	110.3	0.588	Cryer & Parkinson 1999

For further information on biology refer to section 2 of the Introduction – Scallops chapter.

3. STOCKS AND AREAS

It is currently assumed for management that the Coromandel stock is separate from the adjacent Northland stock and from the various west coast harbours, Golden Bay, Tasman Bay, Marlborough Sounds, Stewart Island, and Chatham Island areas.

Dispersal of scallops was investigated at a small spatial and temporal scale in the Coromandel fishery using genetic markers integrated with hydrodynamic modelling. Results showed small but significant spatial and temporal genetic differentiation, suggesting that the Coromandel fishery does not form a single panmictic unit with free gene flow and supporting a model of source-sink population dynamics (Silva 2015).

For further information on scallop habitat and genetic structuring refer to section 3 of the Introduction – Scallops chapter.

4. ENVIRONMENTAL AND ECOSYSTEM CONSIDERATIONS

In the Coromandel scallop stock (SCA CS), a photographic approach was used in the 2006 dredge survey to provisionally examine non-target catch groups (Tuck et al. 2006), but a more quantitative and comprehensive study was conducted using non-target catch data collected in the 2009 dredge survey (Williams et al. 2010) with survey catches quantified by volume of different component categories. Over the whole 2009 survey, scallops formed the largest live component of the total catch volume (26%), followed by assorted seaweed (11%), starfish (4%), other live bivalves (4%), coralline turfing algae (1%), and other live components not exceeding 0.5%. Dead shell (identifiable and hash) formed the largest overall component (45%), and rock, sand, and gravel formed 8%. Categories considered to be sensitive to dredging were caught relatively rarely. Data on non-target catch of the 2010, 2012, 2021 and 2024 dredge surveys of SCA CS were also collected but not analysed because the analysis was not part of the work contracted. Those data have been loaded to the Fisheries New Zealand database ‘scallop’ for potential future analysis (Williams & Parkinson 2010, Williams et al. 2013).

Refer to section 4 of the Introduction – Scallops Chapter for general information on environmental and ecosystem considerations.

5. STOCK ASSESSMENT

From 1990 to 2010, biomass surveys of selected scallop beds in the areas of the fishery that were expected to be fished commercially were conducted annually (excluding 2000 when no survey was conducted), as a means to estimate available biomass in these areas and to inform management decisions on potential increases in the annual TACC. The surveys were conducted using dive sampling only in 1990, a combination of dive and dredge sampling in 1991–1999, and dredge sampling only in 2001–2010. In-season increases in the TACC from 2002 to 2010 were based on the results from a pre-season biomass survey of areas selected in consultation with commercial fishers and the subsequent Current Annual Yield (CAY) estimates, using $F_{0.1}$ as a reference point.

A survey was not conducted in 2011; instead, biomass estimates were calculated using estimates of projected biomass generated by projecting the 2010 survey data forward to the start of the 2011 fishing season. The projection approach used a length-based growth transition matrix (based on tag return data) to grow the scallops from the time of the survey (May 2010) to the start of the fishing season the following year (July 2011), correcting for dredge efficiency, and allowing for natural mortality and fishing mortality (catch and incidental mortality). Uncertainty was incorporated during the projection process by bootstrapping (resampling with replacement) from the various data sources (Tuck 2011).

In 2012, a large-scale survey using dredge sampling was conducted (Williams et al. 2013) that aimed to provide an estimate of abundance within all main areas typically utilised by the commercial fishery. The survey coverage was more extensive than used previously, with the stratification comprising ‘core’ strata (those surveyed and fished consistently in the past), ‘background’ strata (areas of lower densities outside the core strata that formed part of the survey coverage in the past), and ‘new’ strata (those in Hauraki Gulf that had never been surveyed before). There were no large-scale SCA CS surveys carried out from 2013 to 2020, but industry-based dredge surveys of core commercial fishery areas were conducted in 2014 (D. Middleton, unpublished data) and 2015 (Williams 2015), with design and analytical assistance provided by research providers.

A large-scale SCA CS survey was carried out in 2021 that used dredge sampling in commercial fishing areas and dive sampling in non-commercial areas; this involved resurveying the 2012 survey strata and conducting additional sampling in previously unsurveyed areas (Williams et al. 2024a).

Following the 1 April 2022 implementation of a partial closure of the SCA CS fishery, a camera-based survey of the two areas (Te Hauturu-oToi/Little Barrier and Colville Channel) that remained open to fishing in 2022–23 was completed in August 2022 (Williams et al. 2024b).

In 2024, a camera survey was conducted in June–July that provided imagery for analysis using a newly developed Artificial Intelligence (AI) method of scallop detection and sizing, and a dredge survey was carried out in October to provide additional information. The October 2024 dredge survey provided data for estimating biomass in the Bay of Plenty scallop beds (that were not covered by the June–July camera survey) and conducted dredge tows paired with the positions sampled by the camera survey in the Colville Channel and Mercury locations, enabling comparisons of the camera and dredge survey methods (Williams et al. 2025).

The combined spatial areas of key strata consistently sampled in scallop research surveys between 1990 and 2024 in SCA CS commercial fishery locations are shown in Figure 2.

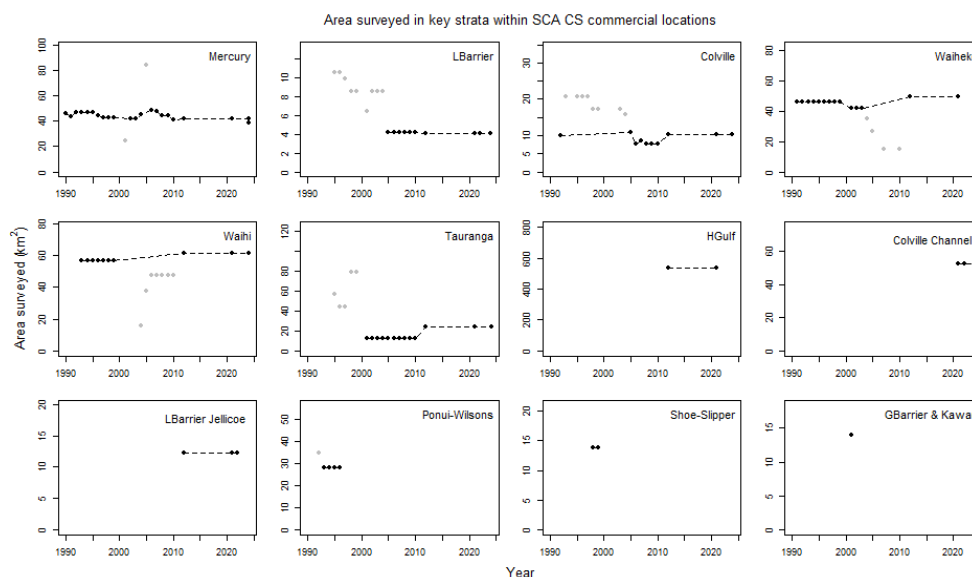


Figure 2: Spatial area (km²) of key strata sampled in scallop research surveys between 1990 and 2024 in SCA CS commercial fishery locations. Note there were two surveys in 2024 for Mercury and Colville Channel: a June–July camera survey and an October dredge survey. Survey coverage has changed over time, which complicates scallop population comparisons. In preliminary work to address this problem, Williams & Bian (2021) selected stratum subsets (‘key strata’, plotted here) to represent the most consistently surveyed areas and used these to estimate scallop biomass by commercial location (see Figure 3). Years with minimal or no change in the area surveyed within key strata are emphasised here using black symbols joined with a dashed line.

5.1 Estimates of fishery parameters and abundance

Fishing mortality estimates have been variable over time in the Coromandel fishery (Table 6). These estimates may be underestimates because they were calculated using estimates of absolute biomass derived using historical estimates of dredge efficiency. A new study of dredge efficiency in 2021 (see Section 5.2 below) suggests that efficiency may be higher than estimated historically, which results in lower estimates of biomass. The level of fishing mortality in recent years is unknown because of the lack of surveys to estimate biomass. There is no established stock-recruit relationship for Coromandel scallops, but high densities of adult scallops within small-scale patches are needed for successful reproduction (synchronous spawning and fertilisation of eggs).

Standardised CPUE from the statutory catch and effort returns is not considered a reliable index of abundance at the stock level (Cryer 2001). Simulation studies have, however, examined the use of local area CPUE as a basis for some management strategies (Haist & Middleton 2014) and the CPUE limit approach was adopted by CSFA in 2010 as a key part of their management approach of the commercial fishery. Smith et al. (2016) noted that the spatial distribution of recent commercial fisheries continues to hold value when used to aid survey designs and should be considered as a way to improve the surveys. Smith et al. (2016) noted that standardisation and agreed methodologies for estimating mean CPUE should be developed, including the need to incorporate catch weighting.

A fishery characterisation and modelling study to evaluate the SCA CS CPUE limit rule management procedure was completed in 2025 (Williams et al. in review). The industry-sourced CPUE data collected during 2010–2021 through the CSFA voluntary logbook programme formed the basis for the investigation. In addition to the CSFA industry data, CELR data for the northern scallop fisheries (SCA 1 and SCA CS) for the period 1991–2021 were analysed to extend the historical context, and fishery-independent survey data collected in SCA CS between 1990 and 2022 were used to assist with mapping the fishery data. This study focused on conducting a detailed spatio-temporal analysis of the CPUE data using a suite of quantitative techniques, to provide a strong evidence base for evaluating the CPUE limit rule management procedure. Results showed that CPUE generally declined both within seasons and across years, indicating localised depletion. Recovery patterns varied by location—some areas rebounded quickly, while others showed limited resilience. Seasonal fishing patterns and a contraction in the fishery’s spatial footprint reflected both ecological and socioeconomic changes. The analysis suggests that neither the CPUE-limit nor the Current Annual Yield (CAY) approach, as previously implemented, adequately monitored or managed high-density scallop aggregations.

5.2 Biomass estimates

From 1990 to 2012, biomass surveys were conducted almost annually. The latest SCA CS biomass surveys were in 2021, 2022 and 2024 (Tables 6 and 7). The SCA CS surveys attempt to estimate current exploitable biomass and gain other information (scallop density, size composition, and spatial distribution) but, because the survey boundaries have been altered over time, the annual biomass estimates are not strictly comparable (Smith et al. 2016).

Average biomass in the absence of fishing, B_0 , and the biomass that will support the maximum sustainable yield, B_{MSY} , have not been estimated. Smith et al. (2016) noted that the survey-based catch rule which used an exploitable biomass estimate to generate a catch limit did not effectively determine stock status in an absolute sense. It was recognised that the survey could estimate suitable catch limits but, without explicit or recognised target and limit reference points, it was not possible to produce a defensible stock status (Smith et al. 2016).

Smith et al. (2016) noted that “given the stochastic recruitment dynamics and spatial heterogeneity in density, growth, and natural mortality of scallops, it may be the case that classical target and limit reference points, which tend to be based on setting specific spawning biomass or fishing mortality levels, are not suitable for scallop fisheries”.

Assessments of SCA CS start-of-season absolute recruited abundance in areas expected to support the fishery in the coming year and biomass estimates were based on pre-season surveys conducted using

diving and/or dredging (Table 6). Bian et al. (2012) modelled the efficiency of box dredges used in northern New Zealand scallop fisheries, and the results suggest that the efficiency of these dredges was underestimated previously (2004 to 2010, Cryer & Parkinson 2006), resulting in overestimation of biomass and yield. The estimates of abundance and biomass for 2012 (Williams et al. 2013) and 2015 (Williams 2015) were made using the Bian et al. (2012) parametric model of dredge efficiency that estimates efficiency with respect to scallop length, water depth, substrate type, and tow termination. A new study of scallop box dredge efficiency was conducted in 2021 using logistic modelling of paired dive-dredge data collected on sandy substrates in SCA CS (Marsh & Williams 2021). Results suggest dredge efficiency may be higher than estimated by Bian et al. (2012). Analysis applying the new efficiency model (Marsh & Williams 2021) in the 2021 survey analysis produced a SCA CS start of season absolute recruited biomass of 308 t meatweight (CV = 17%), compared with 387 t (CV = 14%) estimated using the previous efficiency model (Bian et al. 2012) (Williams et al. 2024a).

Table 6: Estimated start of season abundance and biomass of scallops of 90 mm or more shell length in the Coromandel fishery since 1998 using historical average dredge efficiency; for each year, the catch (reported on the ‘Landed’ section of CELRs), exploitation rate (catch to biomass ratio), and the estimated fishing mortality (F_{est}) are also given. F_{est} was estimated by iteration using the Baranov catch equation where $t = 5/12$ and $M = 0.50$ spread evenly throughout the year. Abundance and biomass estimates are mean values up to and including 2003, and median values from 2004, when the analytical methodology for producing the estimates was modified. Note these estimates were produced by correcting for dredge efficiency using the method of Cryer & Parkinson (2006) for 1998–2010 and the method of Bian et al. (2012) for 2012–21. This, together with changes to survey coverage each year, makes direct comparisons among years difficult. The 2011 values are projected estimates generated by projecting forward the 2010 survey data to the start of the 2011 fishing season. Estimates of abundance in numbers (millions) of scallops were not reported in 2011. Industry-based surveys were conducted in 2014 and 2015, although estimates from the 2014 survey were unavailable for inclusion in this table. – indicates no data. The 2022 camera survey and 2024 camera and dredge surveys did not cover the full area and are not included here (refer to Table 8 for the SCA CS 2022 camera survey estimates).

Year	Abundance		Biomass				Catch (t meat)	Exploitation rate (catch/biomass)	F_{est} ≥ 90 mm
	(millions)	CV	(t green)	CV	(t meat)	CV			
1998	35.4	0.16	2 702	0.16	365	0.16	31	0.08	0.237
1999	10.3	0.18	752	0.18	102	0.18	7	0.07	0.189
2000	–	–	–	–	–	–	10	–	–
2001	8.3	0.26	577	0.27	78	0.27	20	0.26	0.796
2002	10.3	0.20	768	0.20	104	0.20	31	0.30	0.954
2003	16.0	0.18	1 224	0.18	165	0.18	56	0.34	1.131
2004	111.5	0.22	9 024	0.21	1 131	0.26	78	0.07	0.191
2005	169.3	0.24	14 374	0.23	1 795	0.27	121	0.07	0.185
2006	143.1	0.21	12 302	0.21	1 531	0.25	117	0.08	0.212
2007	101.6	0.20	8 428	0.20	1 061	0.23	59	0.06	0.152
2008	94.0	0.29	6 900	0.28	868	0.31	72	0.08	0.232
2009	64.5	0.23	4 676	0.22	595	0.24	33	0.06	0.154
2010	58.8	0.20	4 442	0.19	540	0.21	35	0.07	0.180
2011	–	–	5 426	0.85	658	0.87	50	0.08	0.211
2012	140.0	0.15	11 423	0.15	1 380	0.18	73	0.05	0.145
2013	–	–	–	–	–	–	51	–	–
2014	–	–	–	–	–	–	34	–	–
2015	14.5	0.17	1 065	0.18	128	0.20	27	–	–
2016	–	–	–	–	–	–	27	–	–
2017	–	–	–	–	–	–	32	–	–
2018	–	–	–	–	–	–	27	–	–
2019	–	–	–	–	–	–	13	–	–
2020	–	–	–	–	–	–	10	–	–
2021	39.9	0.13	3 171	0.13	387	0.13	22	0.06	0.152

Note: The 2012 estimates were produced from a comprehensive survey coverage that included previously unsurveyed areas of the SCA CS stock (e.g., the 40–50 m deep region of Hauraki Gulf, which contained a considerable biomass in 2012). The 2021 survey repeated the 2012 survey coverage (979 km²) and sampled additional previously unsurveyed areas (59 km²) including an area in Colville Channel (between Cape Colville and Great Barrier Island).

Table 7: Estimated abundance and biomass of scallops 90 mm or more shell length at the time of surveys in the five main regions of the Coromandel fishery, 1998–2015. It excludes the ‘new’, deep fishery region in Hauraki Gulf, which was fished for the first time in 2011 and surveyed for the first time in 2012 (estimated 148.5 million scallops or 13 278 t greenweight biomass). Also excluded are additional previously unsurveyed areas (59 km²) including an area in Colville Channel (between Cape Colville and Great Barrier Island). Survey data were analysed using a non-parametric re-sampling with replacement approach to estimation (1000 bootstraps). Note these estimates were produced by correcting for dredge efficiency using the method of Cryer & Parkinson (2006). Figures are not necessarily directly comparable among years because of changes to survey coverage. – indicates no survey in a region or year. The 2001 survey totals include scallops surveyed in 7 km² strata at both Kawau (0.5 million, 3 t) and Great Barrier Island (0.8 million, 62 t).

Year	Abundance (millions)						Area surveyed (km ²)
	Barrier	Waiheke	Colville	Mercury	Plenty	Total	
1998	2.0	9.0	0.4	21.3	2.2	36.1	341
1999	0.5	0.5	0.0	7.3	2.7	11.2	341
2001	7.4	0.4	–	6.9	2.1	18.1	125
2002	1.8	4.0	–	6.6	2.0	14.7	119
2003	2.5	4.0	4.3	12.3	4.9	28.6	130
2004	4.5	9.8	0.4	58.5	8.2	82.6	149
2005	6.2	3.3	3.0	118.8	12.6	145.3	174
2006	5.6	–	10.3	101.6	6.5	125.3	160
2007	4.2	1.3	4.4	59.9	14.3	84.6	175
2008	2.0	–	1.7	56.3	4.8	65.0	144
2009	10.4	–	3.1	31.8	1.3	46.9	144
2010	9.6	0.8	2.6	28.0	3.9	45.6	149
2012	7.7	0.4	2.4	22.8	2.9	36.8	180
2015	1.9	–	0.4	9.6	–	11.8	60

Year	Biomass (t greenweight)						Area surveyed (km ²)
	Barrier	Waiheke	Colville	Mercury	Plenty	Total	
1998	173	731	30	1 674	205	2 912	341
1999	42	34	1	559	224	873	341
2001	554	32	–	525	165	1 362	125
2002	150	289	–	538	163	1 156	119
2003	225	302	387	995	406	2 355	130
2004	348	737	30	4 923	676	6 794	149
2005	544	274	316	10 118	1 058	12 404	174
2006	519	–	1 041	8 731	534	10 902	160
2007	376	96	409	5 498	1 110	7 539	175
2008	166	–	150	4 575	367	5 265	144
2009	823	–	257	2 512	102	3 725	144
2010	764	59	219	2 299	291	3 671	149
2012	629	32	250	1 855	225	3 027	180
2015	136	–	27	698	–	861	60

Discerning trends in the abundance and biomass of recruited scallops is complicated by changes to survey coverage, the establishment of closed areas, and uncertainty about dredge efficiency in any particular year. Abundance and biomass estimates of scallops 90 mm or more shell length from 1998 to 2015 are shown in Table 7. It is important to note that these estimates were produced by correcting for dredge efficiency using the method of Cryer & Parkinson (2006); the 2012 onwards values were generated using that same method. For 2012, the estimates were generated using data from the ‘core’ strata only (i.e., the ‘background’ strata, and ‘new’ strata in the Hauraki Gulf region, were excluded—the latter because there was no survey from the past; it was surveyed for the first time in 2012); the areas surveyed are nevertheless not equivalent from year to year. Smith et al. (2016) noted that “The variable coverage of the survey areas over time and the different strata definitions used have resulted in a series of annual estimates that are not always comparable with respect to changes in abundance or biomass over time”. To partially address this issue, historical survey data were reanalysed to estimate time-of-survey absolute biomass of recruited scallops (90 mm or larger shell length) in key (consistently sampled) strata in scallop research surveys between 1990 and 2024 in SCA CS commercial fishery locations (Table 8 and Figure 3). These estimates were produced correcting for dredge efficiency using the method of Marsh & Williams (2021).

Uncertainty stemming from assumptions about dredge efficiency during the surveys, rates of growth and natural mortality between survey and season and predicting the average recovery of meatweight from greenweight remain in these biomass estimates.

Table 8: Time of survey estimated absolute biomass (t meatweight; mean values) of recruited scallops (90 mm or larger shell length) in key scallop surveys strata sampled since 1990 in SCA CS commercial fishery locations. Estimates are scaled using a logistic model of dredge efficiency (Marsh & Williams 2021). Overall survey coverage has changed over time, and Williams & Bian (2021) selected a strata subset to represent the most consistently surveyed areas (see Figure 2). Years with minimal or no change in the area surveyed within key strata are emphasised in Figure 3 using black symbols joined with a dashed line. –, no estimate available.

Year	Mercury	LBarrier	Colville	Waiheke	Waihi Tauranga	HGulf	Colville Channel	LBarrier Jellicoe	Ponui-Wilsons	Shoe-Slipper	GBarrier & Kawau
1990	128	–	–	–	–	–	–	–	–	–	–
1991	109	–	–	47	–	–	–	–	–	–	–
1992	188	–	0	14	–	–	–	–	2	–	–
1993	88	–	3	1	55	–	–	–	1	–	–
1994	46	–	–	0	12	–	–	–	0	–	–
1995	62	27	1	1	7	59	–	–	0	–	–
1996	77	32	1	2	2	16	–	–	1	–	–
1997	57	32	3	62	5	6	–	–	–	–	–
1998	39	10	1	66	1	1	–	–	–	1	–
1999	13	2	0	3	0	3	–	–	–	2	–
2001	11	14	–	2	–	6	–	–	–	–	3
2002	24	8	–	23	–	8	–	–	–	–	–
2003	57	14	26	29	–	21	–	–	–	–	–
2004	185	16	2	63	11	22	–	–	–	–	–
2005	497	27	18	22	33	18	–	–	–	–	–
2006	354	28	54	–	5	20	–	–	–	–	–
2007	238	20	24	6	22	27	–	–	–	–	–
2008	158	8	10	–	11	5	–	–	–	–	–
2009	106	35	19	–	2	2	–	–	–	–	–
2010	35	12	4	1	3	1	–	–	–	–	–
2012	79	31	15	17	2	10	816	–	0	–	–
2021	68	11	8	7	7	13	49	54	8	–	–
2022	–	*0.4	–	–	–	–	–	*36	*4	–	–
2024	*61	*3	*2	–	4	6	–	*11	–	–	–

*Estimates for 2022 and 2024 are from camera surveys except for the 2024 Waihi and Tauranga estimates which were from a dredge survey.

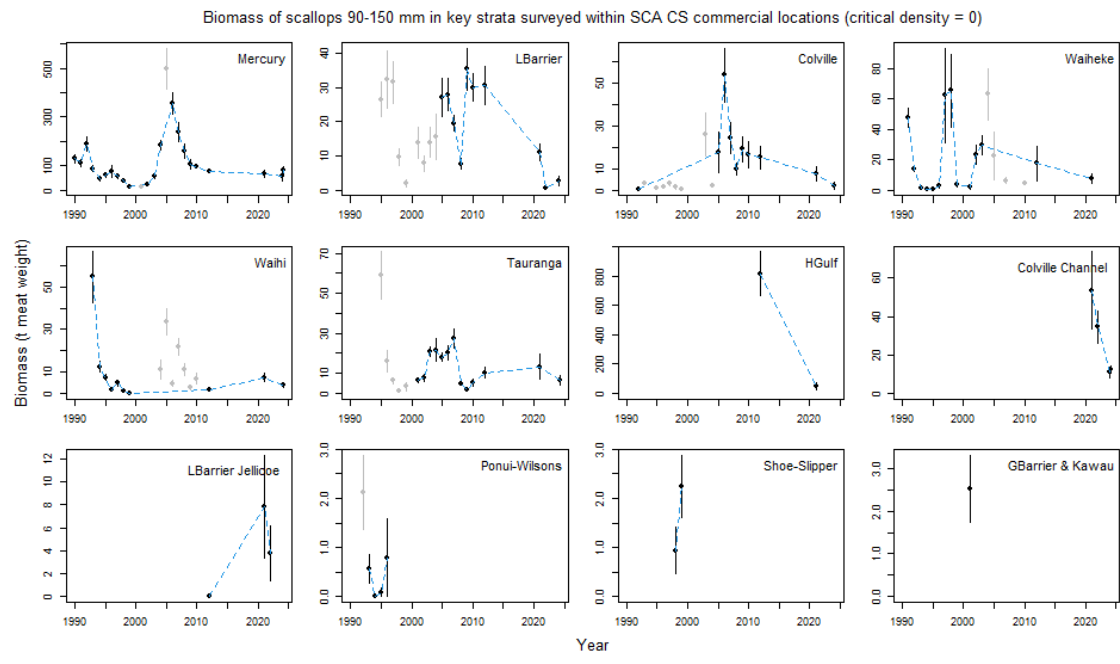


Figure 3: Time of survey estimated absolute biomass (t meatweight; mean and CV) of recruited scallops (90 mm or larger shell length) in key strata sampled in scallop surveys between 1990 and 2024 in SCA CS commercial fishery locations. Estimates derived from dredge survey sampling are scaled using a logistic model of dredge efficiency (Marsh & Williams 2021), and estimates from the June-July 2024 camera survey are adjusted for AI detection efficiency. Note there are two estimates in 2024 for Mercury and Colville Channel, from the June-July camera survey (lower estimate) and the October dredge survey (higher estimate). Overall survey coverage has changed over time, which complicates scallop population comparisons. In preliminary work to address this problem, Williams & Bian (2021) selected stratum subsets (‘key strata’, plotted here) to represent the most consistently surveyed areas (see Figure 2). Years with minimal or no change in the area surveyed within key strata are emphasised here using black symbols joined with a dashed line.

To better enable comparison of the results of the 2012 research survey and 2015 industry survey, data from the 2012 survey were reanalysed using the 2015 survey extent (comprising the core commercial strata fished in SCA CS). Abundance and biomass estimates from this reanalysis are shown in Table 9. The recruited scallop population in the surveyed area of Hauraki Gulf decreased from 77 million in 2012 to 3 million in 2015; in the other areas surveyed in both years, recruited abundance in 2015 (12 million) was about half that in 2012 (23 million).

Table 9: Estimated start-of-season abundance and biomass of scallops of 90 mm or more shell length in core areas of the Coromandel fishery in 2012 and 2015, using historical average dredge efficiency.

Year	Location (grouping)	Area (km ²)	Abundance			Biomass		
			(millions)	CV	(t green)	CV	(t meat)	CV
2012	Barrier	4	6.4	0.23	466	0.20	57	0.24
	H. Gulf	205	77.1	0.23	6 505	0.23	794	0.26
	Colville	10	1.8	0.28	156	0.31	19	0.34
	Mercury	46	15.4	0.16	1 147	0.15	137	0.20
	Total	265	100.4	0.18	8 255	0.19	1 014	0.21
2015	Barrier	4	1.9	0.36	136	0.37	16	0.39
	H. Gulf	205	2.6	0.29	191	0.29	23	0.32
	Colville	10	0.4	0.45	27	0.45	3	0.47
	Mercury	46	9.6	0.25	698	0.25	83	0.29
	Total	265	14.5	0.17	1 065	0.18	128	0.20

Table 10: Dive survey estimates of recruited scallops (100 mm or larger, at the time of the surveys) in 2006–10, 2021 and 2024* in key non-commercial scallop beds in SCA CS (Williams et al. 2025). Stratum names: BOST, Bostaquet Bay; IRIS, Iris Shoal; MERC, Mercury Cove (Home Bay, Great Mercury Island); OPIT, Opito Bay; OMAH, Omaha Bay; and WAIH, Waiheke Island (Hooks Bay / Pakatoa Island). [Continued on next page].

Location	Stratum	Year	Dives		Density CV	Abundance (millions)	(t green)	CV	Biomass (t meat)	
			(n)	(scallops m ⁻²)						
Kawau	BOST	2006	14	0.34	0.29	0.114	12	0.30	1.5	
		2007	14	0.12	0.20	0.042	4	0.20	0.5	
		2008	20	0.10	0.26	0.034	3	0.25	0.4	
		2009	19	0.05	0.32	0.016	2	0.33	0.2	
		2010	22	0.04	0.42	0.012	1	0.43	0.1	
		2021	12	0.01	0.77	0.002	0	0.77	0.0	
	IRIS	2006	16	0.30	0.17	0.201	21	0.17	2.6	
		2007	13	0.09	0.22	0.058	6	0.21	0.8	
		2008	20	0.43	0.15	0.289	29	0.16	3.6	
		2009	13	0.30	0.22	0.201	21	0.22	2.6	
		2010	17	0.10	0.16	0.069	7	0.15	0.9	
	Mercury	MERC	2006	17	0.43	0.37	0.661	75	0.38	9.3
			2007	19	0.31	0.17	0.471	51	0.17	6.4
			2008	20	0.21	0.26	0.313	32	0.26	4.1
2009			24	0.17	0.17	0.258	26	0.17	3.2	
2010			23	0.19	0.18	0.294	29	0.19	3.6	
2021			14	0.01	0.58	0.014	1	0.57	0.2	
2024			12	0.09	0.26	0.138	14	0.26	1.8	
Opito Bay	OPIT	2006	9	0.03	0.33	0.033	4	0.34	0.4	
		2007	8	0	NA	0	0	NA	0.0	
		2008	14	0.02	0.40	0.017	2	0.40	0.2	
		2009	19	0.02	0.30	0.019	2	0.30	0.2	
		2010	26	0.06	0.22	0.065	7	0.22	0.9	
Opito Bay	OPIT	2021	14	0.07	0.25	0.075	8	0.24	1.0	
		2024	14	0.29	0.29	0.312	37	0.30	4.6	
Omaha	OMAH	2021	16	0.08	0.27	0.158	17	0.28	2.1	
Waiheke	WAIH	2021	7	0	NA	0	0	NA	0.0	

*Estimates for 2024 are from a camera survey with AI detection.

Dive surveys of scallops in non-commercial fishing areas were conducted annually in June–July from 2006 to 2010 at selected key scallop beds in Kawau Bay and Mercury Cove/Opito Bay (Williams et al. 2008, Williams 2009a, b, 2012). For the four small beds (total area of 4.64 km²) surveyed each year, the projected (15 July) biomass of scallops over 100 mm shell length was estimated to be 128 t greenweight (CV of 26%) or 16 t meatweight in 2006, 82 t greenweight (CV of 13%) or 10 t meatweight (CV of 20%) in 2007, and 79 t greenweight (CV of 14%) or 10 t meatweight (CV of 21%) in 2008 (Table 10).

Survey stratum boundaries were revised in 2009 to better reflect the extent of the scallop bed at each site, resulting in a slightly reduced total area (3.6 km²) surveyed; the total projected biomass was estimated to be 50 t greenweight or 6 t meatweight (CVs of 13%) in 2009, and 48 t greenweight or 6 t meatweight (CVs of 13% and 16%) in 2010 (Williams 2012). Dive surveys of these same areas, and additional areas in Omaha Bay and at Waiheke Island, were conducted in April–May 2021 (Williams et al. 2024a). For the four beds that were surveyed in 2021, the time-of-survey recruited biomass was a total of 10 t greenweight (1 t at Kawau and 9 t at Mercury/Opito with CVs of 34% and 20%, respectively); recruited biomass in 2021 in Omaha Bay was 17 t (CV = 27%) and was zero at Waiheke (scallops of legal size were not encountered during the survey). Time series of recruited density in the non-commercial areas surveyed by diving are shown in Figure 4. Although density had increased at Opito Bay, recruited densities were low in all beds surveyed, particularly those at Kawau and at Great Mercury Island (Mercury Cove). The Mercury Cove and Opito Bay beds were resurveyed in the 2024 camera survey with AI detection, and the results suggest significant population recovery at Opito Bay and moderate recovery at Mercury Cove.

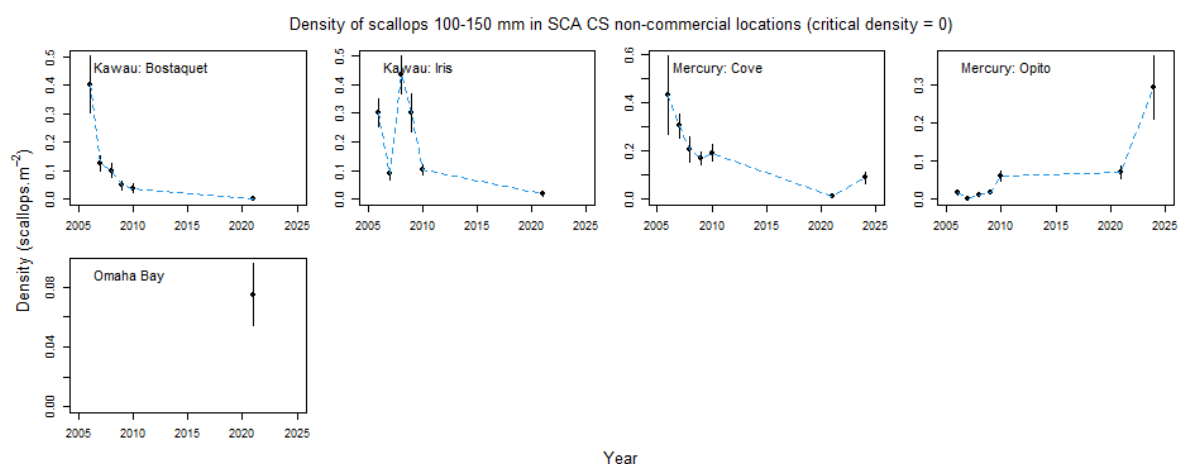


Figure 4: Time series of scallop density in Coromandel SCA CS non-commercial scallop locations surveyed between 2006 and 2021 using dive surveys and in 2024 using a camera survey with AI detection. The 2024 estimates are adjusted for AI detection efficiency. Waiheke Island strata ‘Hooks’ and ‘Pakatoa’ are not shown because no legal-sized scallops were encountered during the 2021 survey.

5.3 Estimation of Target Harvest (Exploitation) Rate

Until 1997, assessments for the Coromandel fishery were based on Provisional Yield (PY, estimated as the lower bound of a 95% confidence distribution for the estimated start-of-season biomass of scallops 100 mm or more shell length). However, experiments and modelling showed this method to be sub-optimal. New estimates of the reference fishing mortality rates $F_{0.1}$, $F_{40\%}$, and F_{max} were made, taking into account experimental estimates of incidental fishing mortality. For assessments since 1998, CAY was estimated using these reference fishing mortality rates. Experimentation and modelling of juvenile mortality in relation to habitat heterogeneity suggest that these reference fishing mortality rates may be too high, and Haist & Middleton (2014) found that lower survey multipliers would be required to meet the risk criteria of the Harvest Strategy Standard.

Yield estimates are generally calculated using reference rates of fishing mortality applied to an estimate of current or reference biomass. Cryer & Parkinson (2006) reviewed reference rates of fishing mortality

and summarised modelling studies by Cryer & Morrison (1997) and Cryer et al. (2004). $F_{0.1}$ is used as the target reference rate of fishing mortality for scallops. From 1998 to 2012, catch limits have been adjusted in line with estimated start-of-season recruited biomass and an estimate of CAY made using the Baranov catch equation:

$$CAY = \frac{F_{ref}}{F_{ref} + M} (1 - e^{-(F_{ref}+M)t}) B_{beg}$$

where $t = 5/12$ years, F_{ref} is a reference fishing mortality ($F_{0.1}$), and B_{beg} is the estimated start-of-season (15 July) recruited biomass (scallops of 90 mm or more shell length). Natural mortality is assumed to act in tandem with fishing mortality for the first five months of the fishing season, the length of the current Coromandel commercial scallop season. B_{beg} is estimated assuming historical average dredge efficiency at length, average growth (from previous tagging studies), $M = 0.5$ spread evenly through the year, and historical average recovery of meatweight from greenweight. Because of the uncertainty over biomass estimates, growth and mortality in a given year, and appropriate reference rates of fishing mortality, yield estimates must be treated with caution.

Modelling studies for Coromandel scallops (Cryer & Morrison 1997, Cryer et al. 2004) indicate that $F_{0.1}$ is sensitive not only to the direct incidental effects of fishing (reduced growth and increased mortality on adult scallops), but also to indirect incidental effects (such as additional juvenile mortality related to reduced habitat heterogeneity in dredged areas). By including only the direct incidental effects of fishing on scallops, Cryer et al. (2004) derived an estimate of $F_{0.1} = 1.034 \text{ y}^{-1}$ (reported by Cryer et al. 2004, as $5/12 \times F_{0.1} = 0.431$). Cryer et al. (2004) also modelled the ‘feedback’ effects of habitat modification by the dredge method on juvenile mortality in scallops. They developed estimates of F_{ref} that incorporated such effects, but they had to make assumptions about the duration of what they called the ‘critical phase’ of juvenile growth during which scallops were susceptible to increased mortality. To give some guidance on the possible outcome of including ‘indirect’ (as well as direct) effects on yield estimates, the Cryer et al. (2004) estimate of $F_{0.1} = 0.658 \text{ y}^{-1}$ (reported as $5/12 \times F_{0.1} = 0.274$) was also applied in calculations of CAY.

For both scenarios, the estimates of CAY would have CVs at least as large as those of the estimate of start-of-season recruited biomass, are sensitive to assumptions about dredge efficiency, growth, and expected recovery of meatweight from greenweight, and relate to the surveyed beds only. Further, the second approach, which includes indirect incidental effects (putative ‘habitat effects’), is sensitive to the duration of any habitat-mediated increase in juvenile mortality. There is also additional uncertainty associated with using a point estimate of $F_{0.1}$ (i.e., variance associated with the point estimate of $F_{0.1}$ was not incorporated in the analysis), and the fact that the estimates of $F_{0.1}$ were generated using estimates of dredge efficiency that are different to those used to estimate current biomass; the latter may have resulted in underestimates of yield.

The most recent CAY estimates for SCA CS were derived in 2012, calculated using the two different estimates of $F_{0.1}$ ($F_{0.1} = 1.034 \text{ y}^{-1}$ or 0.658 y^{-1}) and the estimated start of season absolute recruited biomass. Advances in scallop assessment since that time (Haist & Middleton 2014, Orensanz et al. 2016, Smith et al. 2016) suggested that these estimates of $F_{0.1}$ are too high.

A review of reference points (management targets and limits) for scallop fisheries was undertaken in 2025; a brief summary of the review is provided in section 5 of the Introduction – Scallops chapter, and the findings will be published in a forthcoming report (Williams & Underwood, in review).

6. FUTURE RESEARCH CONSIDERATIONS

Future research should focus on:

- Designing and implementing an improved monitoring programme for scallops including establishing appropriate monitoring metrics and the priority and most representative areas to be monitored. The 2024 camera, dive and dredge surveys of scallops in SCA 1 and SCA CS (Williams et al. 2025) have demonstrated the potential of non-extractive and low impact ROV survey methods, but there are still limitations. Broader-scale mapping of scallop distribution could be possible as technology advances further stock. A combination of methods (i.e., both fishery-independent surveys and fishery-dependent data) is desirable to give different perspectives, noting that monitoring needs to be both timely and cost-effective, to inform fisheries management decisions soon after completion of the data collection and analysis. Camera surveys will be particularly efficient once the technology enables autonomous operation and coverage of a lot more of the seabed. This scaling up of sampling and automated processing will however continue to rely on a need to check and validate (i.e., through diving) the data collected with the camera and analysed with the AI.
- Assessing stock status in relation to appropriate reference points.

Ongoing and future research will play a critical role in informing the development of more effective scallop fishery management strategies. A current project reviewing reference points for scallops will provide guidance on appropriate biological targets and limits (Williams & Underwood in review). Potential future research ideas include:

- **Enhancing fishery data collection.** Ongoing refinement of ER systems will improve the spatial and temporal resolution of catch and effort data, enabling more timely, accurate and fine-scale insights, supporting more responsive and effective management decisions. High-resolution fishery data is desirable for understanding total catch across commercial, recreational and customary sectors.
- **Simulation modelling of alternative management strategies.** Modelling could be used to evaluate the effectiveness of spatially structured management approaches which have designated areas open and closed to fishing, the latter including inter-annual rotational closures and permanent no-take areas.
- **Investigating environmental and climate drivers of scallop dynamics.** Existing survey and fishery datasets offer valuable opportunities to explore relationships between oceanographic variables and scallop abundance. Understanding these drivers, including those affected by climate change, can support the development of predictive models of natural variability, for informing adaptive management strategies in the face of changing ocean conditions. Identifying the underlying patterns and drivers of recruitment and mortality could help improve our understanding of bed resilience. One factor contributing to resilience is having multiple cohorts present within a bed, which may buffer the population against environmental impacts or fishing pressure. This structural diversity could play a key role in maintaining bed stability and productivity over time.
- **Studying population connectivity.** Research into larval dispersal and genetic connectivity between scallop beds is essential for optimising spatial management and ensuring the resilience of the stock across locations. In the absence of robust connectivity information, a precautionary approach should be used, by separately managing each subarea (e.g., fishery ground or location) within the overall QMA. If new data provide evidence of connectivity between particular subareas, then management can be adapted accordingly.

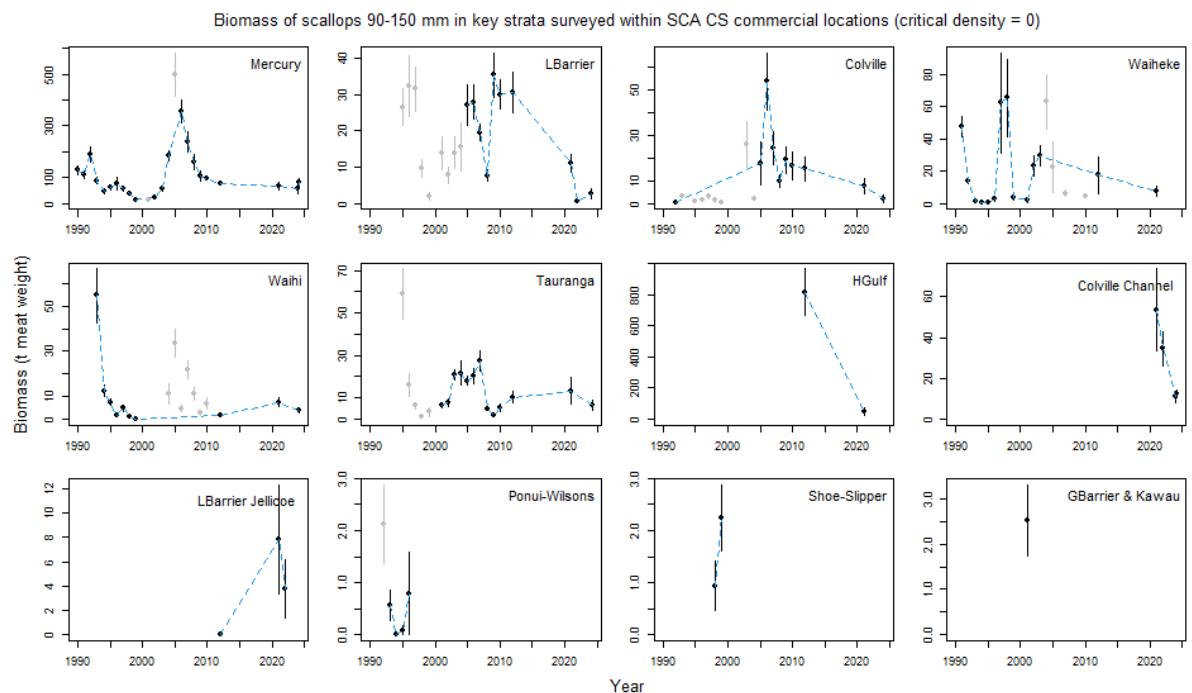
7. STATUS OF THE STOCKS

Stock structure assumptions

The stock structure of scallops in New Zealand waters is uncertain. For the purposes of this assessment, SCA CS is assumed to be a single biological stock, although the extent to which the various beds or populations are reproductively or functionally separate is not known.

Stock Status	
Most Recent Assessment Plenary Publication Year	2021: large-scale dive and dredge surveys and 2024: camera surveys and dredge surveys
Intrinsic productivity level	High
Catch in most recent year of assessment	Year: Catch:
Assessment Runs Presented	Series of biomass estimates with varying survey areas
Reference Points	Target: Fishing mortality at or below F_{MSY} as approximated by $F_{0.1}$ Soft Limit: 20% B_0 Hard Limit: 10% B_0 Overfishing threshold: F_{MSY} as approximated by $F_{0.1}$
Status in relation to Target	Unknown
Status in relation to Limits	Unknown
Status in relation to Overfishing	Overfishing Unlikely (< 40%) to be occurring - fisheries closed

Historical Stock Status Trajectory and Current Status



Time of survey estimated absolute biomass (t meatweight; mean and CV) of recruited scallops (90 mm or larger shell length) in key strata sampled in scallop research surveys between 1990 and 2024 in SCA CS commercial fishery locations. Estimates derived from dredge survey sampling are scaled using a logistic model of dredge efficiency (Marsh & Williams 2021), and estimates from the June-July 2024 camera survey are adjusted for AI detection efficiency. Note there are two estimates in 2024 for Mercury and Colville Channel, from the June-July camera survey (lower estimate) and the October dredge survey (higher estimate). Overall survey coverage has changed over time, and years with minimal or no change in the area surveyed within key strata are emphasised here using black symbols joined with a dashed line.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Overall biomass from surveys of the main beds declined to about a third of the 2012 level by 2021. The level of change varied between beds, with some (Mercury and those in the Bay of Plenty) being comparable between surveys or showing an increase. Biomass declined further at Little Barrier and in Colville Channel between 2021 and 2022. Biomass in 2024 was similar to or lower than biomass in 2021 and 2022 except for at Mercury where biomass had increased in some strata but decreased in others, and at Little Barrier where there was evidence of a small increase.
Recent Trend in Fishing Intensity or Proxy	Annual landings have followed a declining trend since 2012. The fishery was partially closed in April 2022, and fully closed in December 2022.
Other Abundance Indices	-
Trends in Other Relevant Indicator or Variables	-

Projections and Prognosis	
Stock Projections or Prognosis	Stock projections are not available. Catch, catch rates, and growth are highly variable both within and among years. Recruitment is also highly variable between years.
Probability of Current Catch or TACC causing Biomass to remain below or to decline below Limits	Soft Limit: Unknown Hard Limit: Unknown
Probability of Current Catch or TACC causing Overfishing to continue or to commence	Unlikely (< 40%) – fisheries closed

Assessment Methodology and Evaluation		
Assessment Type	Level 2 – Partial Quantitative Stock Assessment	
Assessment Method	Biomass surveys	
Assessment Dates	Latest assessment Plenary publication year: 2024	Next assessment: Unknown
Overall Assessment Quality Rank	1 – High Quality	
Main data inputs (rank)	Biomass survey: 2024	1 – High Quality
Data not used (rank)	N/A	
Changes to Model Structure and Assumptions	N/A	
Major Sources of Uncertainty	<ul style="list-style-type: none"> - consistency of survey spatial coverage - dredge efficiency during the survey - dredge efficiency variability between substrates and between different environmental conditions - growth rates and natural mortality between the survey and the start of the season - predicting the average recovery of meatweight from greenweight - the extent to which dredging causes incidental mortality and affects recruitment 	

Qualifying Comments
In the Coromandel fishery some scallop beds are persistent, and others are ephemeral. The extent to which the various beds or populations are reproductively or functionally separate is not known.

8. FOR FURTHER INFORMATION

- Bian, R; Williams, J R; Smith, M; Tuck, I D (2012) Modelling dredge efficiency for the Coromandel and Northland scallop fisheries. Final Research Report for Ministry of Fisheries project SAP200913. 46 p. (Unpublished report held by Fisheries New Zealand, Wellington.)
- Boyd, R O; Gowing, L; Reilly, J L (2004) 2000–2001 national marine recreational fishing survey: diary results and harvest estimates. (Unpublished New Zealand Fisheries Assessment Research Report for the Ministry of Fisheries Project REC2000-01 held by Fisheries New Zealand, Wellington.) 92 p.
- Boyd, R O; Reilly, J L (2004) 1999/2000 National Marine Recreational Fishing Survey: harvest estimates. (Unpublished New Zealand Fisheries Assessment Research Report for the Ministry of Fisheries Project REC9803 held by Fisheries New Zealand, Wellington.) 28 p.
- Bradford, E (1998) Harvest estimates from the 1996 national marine recreational fishing surveys. *New Zealand Fisheries Assessment Research Document 98/16*. 27 p.
- Cryer, M (2001) An appraisal of an in-season depletion method of estimating biomass and yield in the Coromandel scallop fishery. *New Zealand Fisheries Assessment Report 2001/8*. 28 p.
- Cryer, M; Davies, N M; Morrison, M (2004) Collateral damage in scallop fisheries: translating ‘statistics’ into management advice. Presentation and working document for Shellfish Fishery Assessment Working Group, March 2004. (Unpublished report held by Fisheries New Zealand, Wellington.)
- Cryer, M; Morrison, M (1997) Yield per recruit in northern commercial scallop fisheries: inferences from an individual-based population model and experimental estimates of incidental impacts on growth and survival. Final Research Report for Ministry of Fisheries project AKSC03. 67 p. (Unpublished report held by Fisheries New Zealand, Wellington.)
- Cryer, M; Parkinson, D M (1999) Dredge surveys and sampling of commercial landings in the Northland and Coromandel scallop fisheries, May 1998. *NIWA Technical Report 69*. 63 p.
- Cryer, M; Parkinson, D M (2006) Biomass surveys and stock assessments for the Coromandel and Northland scallop fisheries, 2005. *New Zealand Fisheries Assessment Report 2006/34*. 53 p.
- Dredge, M C L; Marsden, I D; Williams, J R (2016) Scallop Fisheries, Mariculture and Enhancement in Australasia. In: Shumway, S E; Parsons, G J (eds) *Scallops: Biology, Ecology, Aquaculture, and Fisheries*, pp. 1127–1170. *Developments in Aquaculture and Fisheries Science, Volume 40*. Elsevier Science, Amsterdam, Holland.
- Fisheries New Zealand (2022a) Review of Sustainability Measures for the 2022 April Round. Fisheries New Zealand Decision Paper. 150 p.
- Fisheries New Zealand (2022b) Review of sustainability measures for scallop (SCA CS) for 2023/24. Fisheries New Zealand Discussion Paper No: 2022/21. 29 p.
- Fisheries New Zealand (2023) Review of Sustainability Measures for the 2023 April round. Fisheries New Zealand Decision Paper. 44 p.
- Haist, V; Middleton, D A J (2014) Management strategy evaluation for the Coromandel scallop fishery. *New Zealand Fisheries Assessment Report 2014/48*. 66 p.
- Heinemann A; Gray, A. (2024) National Panel Survey of Recreational Marine Fishers 2022-23. *New Zealand Fisheries Assessment Report 2024/51*. 116 p.
- Holdsworth, J C; Walshe, K (2014) Amateur harvest estimates for scallop and rock lobster fisheries from the eastern Coromandel, New Zealand 2007–08. *New Zealand Fisheries Assessment Report 2014/56*. 31 p.
- MacDonald, B A; Bricelj, M; Shumway, S E (2016) Physiology: Energy Acquisition and Utilisation. In: Shumway, S E; Parsons, G J (eds) *Scallops: Biology, Ecology, Aquaculture and Fisheries*, pp. 301–353. *Developments in Aquaculture and Fisheries Science, Volume 40*. Elsevier, Amsterdam, Holland.
- Marsh, C; Williams, J R (2021) SCA CS dredge efficiency: Project SEA2020-07 results. Presented at the Fisheries New Zealand Shellfish Working Group. Online presentation, 19 October 2021.
- Minister for Oceans and Fisheries (2022) Decision Letter: Changes to fisheries sustainability for the 2022 April Round. 12 p. (<https://www.mpi.govt.nz/dmsdocument/50542-Minister-for-Oceans-and-Fisheries-decision-letter-Review-of-sustainability-measures-for-selected-fish-stocks-April-2022-round>).
- Ministry for Primary Industries (2013) Coromandel scallops (SCA CS): Total Allowable Catch Review Final Advice. Final Advice Paper to the Minister for Primary Industries. 46 p. (Unpublished report held by Fisheries New Zealand, Wellington.)
- Ministry for Primary Industries (2016) Review of Sustainability Controls for the Coromandel Scallop Fishery. *MPI Discussion Paper No: 2016/04*. 12 p.
- Ministry of Fisheries (2007) Draft Coromandel scallop fisheries plan, May 2007. Accessed last on 3/12/2021 at <https://fs.fish.govt.nz/Doc/16400/CoromandelscallopFisheriesPlanDraftforcommentMay2007.pdf.ashx>.
- Orensanz, J M; Parma, A M; Smith, S J (2016) Dynamics, Assessment and Management of Exploited Natural Populations. In: Shumway, S E; Parsons, G J (eds) *Scallops: Biology, Ecology and Aquaculture*, pp. 611–695. *Developments in Aquaculture and Fisheries Science, Volume 40*. Elsevier, Amsterdam, Holland.
- Silva, C N S (2015) Spatial and temporal genetic structure of the New Zealand scallop *Pecten novaezelandiae*: A multidisciplinary perspective. PhD thesis, Victoria University of Wellington. 158 p.
- Silva, C N S; Gardner, J P A (2015) Emerging patterns of genetic variation in the New Zealand endemic scallop *Pecten novaezelandiae*. *Molecular Ecology* 24: 5379–5393.
- Silva, C N S; Gardner, J P A (2016) Identifying environmental factors associated with the genetic structure of the New Zealand scallop: linking seascape genetics and ecophysiological tolerance. *ICES Journal of Marine Science: Journal du Conseil* 73: 1925–1934.
- Smith, S; Hart, D; Haddon, M (2016) Review of New Zealand’s scallop fishery stock assessment data and methods. *New Zealand Fisheries Science Review* 2016/1. 25 p.
- Talman, S G; Norkko, A; Thrush, S F; Hewitt, J E (2004) Habitat structure and the survival of juvenile scallops *Pecten novaezelandiae*: comparing predation in habitats with varying complexity. *Marine Ecology Progress Series* 269: 197–207.
- Teirney, L D; Kilner, A R; Millar, R B; Bradford, E; Bell, J D (1997) Estimation of recreational harvests from 1991–92 to 1993–94. *New Zealand Fisheries Assessment Research Document 97/15*. 43 p.
- Tuck, I; Parkinson, D; Dey, K; Oldman, J; Wadhwa, S (2006) Information on benthic impacts in support of the Coromandel Scallops Fishery Plan. Final Research Report prepared by NIWA for Ministry of Fisheries Research Project ZBD2005-15 Objective 1-6. p. (Unpublished report held by Ministry for Primary Industries, Wellington.)
- Tuck, I D (2011) Utility of scallop surveys in predicting future year’s CAY. Final Research Report for Ministry of Fisheries project SEA2010-11. 29 p. (Unpublished report held by Fisheries New Zealand, Wellington.)

SCALLOPS (SCA CS) – Nov 2025

- Walshe, K A R (1984) A study to determine the optimum number of licences for the Tauranga commercial scallop fishery based on an optimum yield estimate. (Unpublished report for Diploma in Business and Administration, Massey University, Palmerston North, New Zealand.)
- Williams, J R (2009a) Abundance of scallops (*Pecten novaezelandiae*) in Coromandel recreational fishing areas, 2008. *New Zealand Fisheries Assessment Report 2009/8*. 18 p.
- Williams, J R (2009b) Abundance of scallops (*Pecten novaezelandiae*) in Northland and Coromandel recreational fishing areas, 2007. *New Zealand Fisheries Assessment Report 2009/62*. 22 p.
- Williams, J R (2012) Abundance of scallops (*Pecten novaezelandiae*) in Coromandel recreational fishing areas, 2009 and 2010. *New Zealand Fisheries Assessment Report 2012/24*. 29 p.
- Williams, J R (2015) CSFA survey of scallops in SCA CS, June–July 2015. Report to Coromandel Scallop Fishermen's Association. 7 p. (Unpublished report held by NIWA, Auckland.)
- Williams, J R; Bian, R (2021) SCA 1 and SCA CS survey time series 1990-2021: Projects SCA2020-02 and SEA2020-07. Presented at the Fisheries New Zealand Shellfish Working Group. Online presentation, 19 October 2021.
- Williams, J R; Bian, R; Hughes, R; Rensen, T; Underwood, M J (2025) Camera, dive and dredge surveys of scallops in SCA 1 and SCA CS, 2024. *New Zealand Fisheries Assessment Report 2025/16*. 72 p.
- Williams, J R; Bian, R; Middleton, C M; Hughes, R; Evans, O; Buckthought, D; Parkinson, D; Taylor, R (2024a) Dive and dredge surveys of scallops in SCA 1 and SCA CS, 2021. *New Zealand Fisheries Assessment Report 2024/36*. 64 p.
- Williams, J.R.; Grüss, A.; Bian, R. (in review). Evaluation of the CPUE limit rule management procedure for the Coromandel scallop fishery (SCA CS). Draft New Zealand Fisheries Assessment Report. 74 p.
- Williams, J R; Hughes, R; Jordan, L; Middleton, C J; Middleton, I; Underwood, M J (2024b) Camera survey of scallops in the Te Hauturu-o-Toi/Little Barrier Island and Colville Channel areas within SCA CS. *New Zealand Fisheries Assessment Report 2024/66*. 39 p.
- Williams, J R; Parkinson, D M (2010) Biomass survey and stock assessment for the Coromandel scallop fishery, 2010. *New Zealand Fisheries Assessment Report 2010/37*. 30 p.
- Williams, J R; Parkinson, D M; Bian, R (2013) Biomass survey and yield calculation for the Coromandel scallop fishery, 2012. *New Zealand Fisheries Assessment Report 2013/18*. 57 p.
- Williams, J R; Parkinson, D M; Tuck, I D (2010) Biomass survey and stock assessment for the Coromandel scallop fishery, 2009. *New Zealand Fisheries Assessment Report 2010/33*. 40 p.
- Williams, J R; Tuck, I D; Carbines, G D (2008) Abundance of scallops (*Pecten novaezelandiae*) in Northland and Coromandel recreational fishing areas, 2006. *New Zealand Fisheries Assessment Report 2008/34*. 23 p.
- Williams, J.R.; Underwood, M.J. (in review). Review of reference points (management targets and limits) for scallops. *New Zealand Fisheries Assessment Report 20xx/xx*. xx p.
- Williams, J R; Underwood, M J; Rensen, T; Hughes, R; Bian, R; Middleton, C; Evans, O; Middleton, I (2025) Camera, dive, and dredge surveys of scallops in SCA 1 and SCA CS, 2024. *New Zealand Fisheries Assessment Report 2025/16*. 72 p
- Wynne-Jones, J; Gray, A; Heinemann, A; Hill, L; Walton, L (2019) National Panel Survey of Marine Recreational Fishers 2017–2018. *New Zealand Fisheries Assessment Report 2019/24*. 104 p.
- Wynne-Jones, J; Gray, A; Hill, L; Heinemann, A (2014) National panel survey of marine recreational fishers 2011–12: Harvest estimates. *New Zealand Fisheries Assessment Report 2014/67*. 139 p.